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EVALUATION OF COMMERCIAL UTILITY OF ERTS-A IMAGERY IN STRUCTURAL RECONNAISSANCE FOR MINERALS AND PETROLEUM

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ABSTRACT

Five areas in North America (North Slope-Alaska, Superior Province-Canada, Williston Basin-Montana, Colorado and New Mexico-West Texas) are being studied for discernibility of geological evidence on ERTS-A imagery. Evidence mapped is compared with known mineral/hydrocarbon accumulations to determine the value of the imagery in commercial exploration programs.

Evaluation has proceeded in the New Mexico-West Texas area while awaiting imagery in the other areas. To date, results have been better than expected. Clearly discernible structural lineaments in New Mexico-West Texas are evident on the photographs. Comparison of this evidence with known major mining localities in New Mexico indicates a clear pattern of coincidence between the lineaments and mining localities.

In West Texas, lineament and geomorphological evidence obtainable from the photographs define the petroleum-productive Central Basin Platform.

Based on evaluation results in the New Mexico-West Texas area and on cursory results in the other four areas of North America, ERTS-A imagery will be extremely valuable in defining the regional and local structure in any commercial exploration program.

INTRODUCTION

Practical utilization of ERTS imagery to solve resource and environmental problems is a chief goal in the ERTS program. A strong test of practicality is provided in determining the commercial utility of the imagery in the photogeologic service business where future successful resource exploration will require innovative approaches incorporating industrial-governmental-academic cooperation and exchange of knowledge as is evident in the ERTS Program.

One such potential commercial application is the use of ERTS imagery in reconnaissance exploration for minerals and petroleum. Whether satellite imagery at a scale of 1:1,000,000 can be useful in such exploration programs is the question to be answered in this study.

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STUDY AREAS AND METHODS

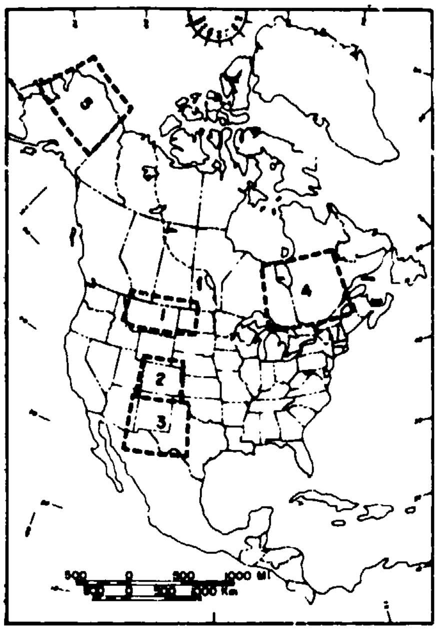

Fig. 1 - INDEX MAP - ERTS-A STUDY AREAS

Five areas in North America (Fig. 1) were chosen to be studied on ERTS-A imagery. These areas were picked for geologic, physiologic and climatic variations to an extent necessary to adequately evaluate the imagery.

ERTS-A imagery in the form of photo prints were mosaiced for each area and studied for geologic and geomorphic data separately by the two investigators of this study. The principle type of data discernible on the photos is in the form of fracture patterns emphasized by the drainage patterns of the areas. In many instances, the fracture patterns in conjunction with tonal alignments form lineaments that may extend for several hundred miles.

The data obtained independently by the two investigators is then compared for coincidence to establish visual validity for the mapped data. Valid data are then compared to "known" faults, fractures and lineaments in each area to establish coincidence of data. Known mining localities as well as petroleum producing sites are also compared with the mapped data to obtain any possible correlations useful to the evaluation.

STUDY BACKGROUND

Several recent papers (see References) have pointed out the ore deposits "belts" in various parts of North America and their possible association with recognized major lineaments. Other authors interested in petroleum deposits have suggested the importance of lineaments in controlling faults and folds in the stratigraphic section as well as ancient shelfs and basins. Both types of studies utilize ore or hydrocarbon production trends to define possible lineaments.

Investigators of regional fracture or lineament patterns such as Cloos (1948) and Vening Meinesz (1947) have arrived at the conclusion that these patterns are of an early Precambrian age and predate the subsequent orogenic and depositional history of the earth.

Figure 2 shows a portion of the world-wide lineament pattern of Precambrian age as defined in North America by the investigators of this study. Lineament criteria includes structural and lithologic linear zones as well as geomorphic major linear trends. Only the northeast and northwest lineaments are shown here as these are believed to represent the primordial pattern with other lineament trends being generated later during the Precambrian.

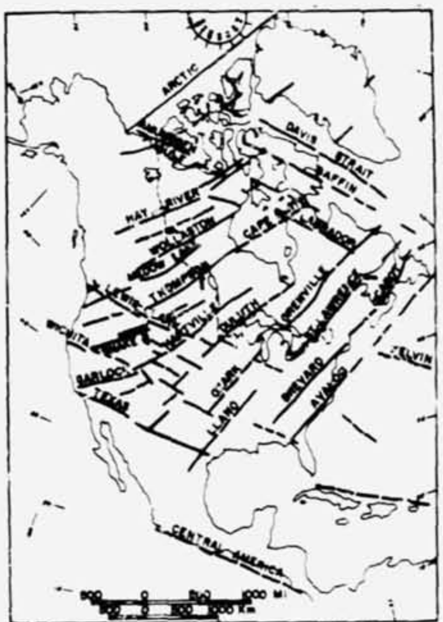

Fig. 2 - NORTH AMERICA: NE-NW MAJOR LINEAMENTS

Prior to the ERTS program, the above-mentioned lineament studies as well as that shown in Figure 2 have had to define lineaments indirectly from linear geologic-geomorphic trends. ERTS imagery now allows for the first time a visual perspective that should confirm or deny many of these previously postulated lineaments. In addition, ERTS imagery should provide a means to add a great amount of secondary fracture-lineament data that may prove useful in commercial exploration ventures.

STUDY RESULTS

Plate 1 - Photo mosaic of ERTS-A photos in Area 3

Although five areas in North America were chosen to be studied, difficulties in receiving useable ERTS imagery in four of the five areas have limited the results as of this writing, to the Arizona, New Mexico, West Texas and Mexico area which is shown here as a small-scale, reduced mosaic of the ERTS photos in the area (Pl. 1). Results in this area have been better than expected especially in view of the rather dark tonal quality of the photo prints. Regional, northeast-trending lineaments are evident on the ERTS

photos in this area as well as parts of the northwest-trending Texas lineaments zone. These ERTS-defined lineaments (from the small-scale mosaic only) are shown as dotted lines (Fig. 3) in comparison with the published lineaments of the area. The northeast-trending lineaments have not been recognized before as being so numerous nor as clearly evident in the area. Even at the extremely small-scale mosaic of ERTS photos, it is possible to add to the data known in the area.

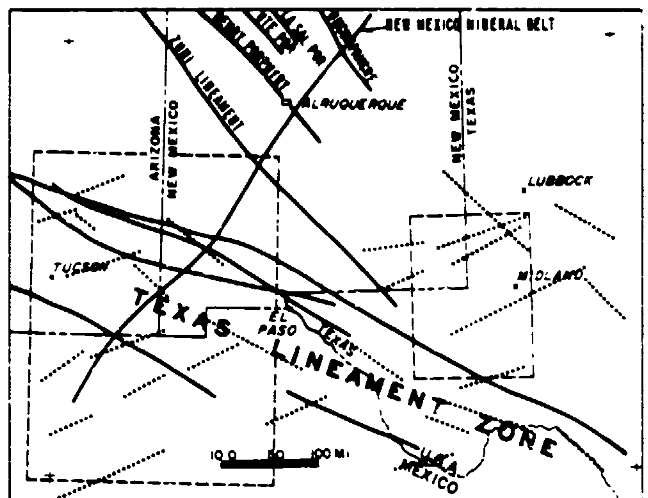

Fig. 3 - ERTS AREA 3 - KNOWN LINEAMENTS AND ERTS NEW LINEAMENTS (DOTTED LINES).

Two local areas, however, within Area 3 are especially interesting in relation to ERTS data and commercial utilization of the data. These two areas are shown by the dashed-line area outlines in Figure 3.

MINING DISTRICT: ARIZONA, NEW MEXICO, MEXICO

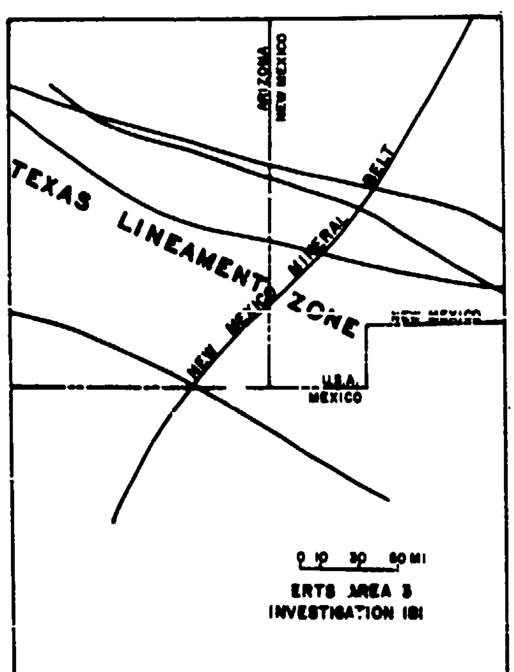

Fig. 4 - NEW MEXICO - ARIZONA - MEXICO KNOWN LINEAMENTS

Northeast-trending lineaments in this mining district are clearly discernible on ERTS photos (lower left corner Pl. 1). In addition, subtle northwest-trending and nearly east-west lineaments are also discernible. "Known" lineaments in the area, however, are few and consist of only two major lineament trends, the New Mexico Mineral Belt (Jerome and Cook, 1967) and the various positions of the Texas Lineament zone (Kelley, 1955; Schmitt, 1966; Wertz, 1970) as shown in Figure 4.

Even with showing just the more prominent lineaments as obtained from the ERTS photos in the area (Fig. 5), there is a decided increase in data in the area thanks to the ERTS mapping medium. While this in itself could aid a commercial exploration program in the area, the plotting of the major mining districts in the area in relation to the ERTS new lineaments adds an even greater exploration perspective to the area. Invariably, the major mining districts are near coincident with the prominent northeast-trending lineaments. Secondly, the districts appear to occur along the northeast lineaments where the subtle east-west, east-southeast lineaments intersect the northeast features. Just based on this relationship for prominent new lineaments and major mining districts it is possible to postulate other prospective sites in the area where this lineament relationship occurs (Fig. 5). If this can be done using 1:1,000,000 scale photos, it is interesting to wonder just how much more accurate prospective sites could be defined if 1:250,000 scale photo enlargements were used to map even greater amounts of fracture-lineament data.

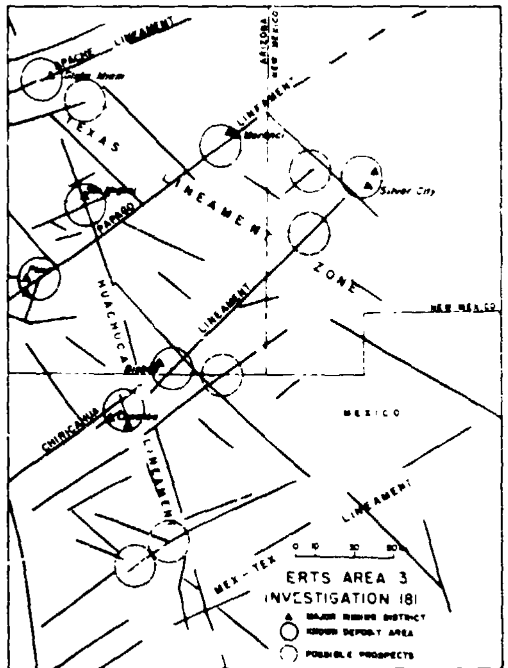

Fig 5 - NEW MEXICO - ARIZONA - MEXICO ERTS LINEAMENTS - MAJOR MINING DISTRICTS

CENTRAL BASIN PLATFORM, WEST TEXAS

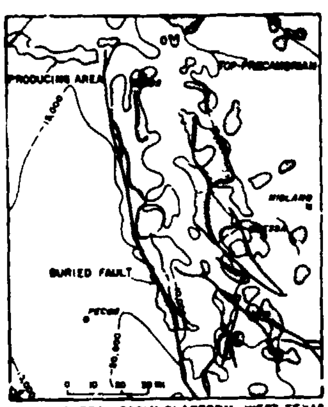

Fig. 6 - CENTRAL BASIN PLATFORM, WEST TEXAS KNOWN STRUCTURAL FEATURES

In west Texas the Tectonic Map of the U. S. (1962) defines the Central Basin platform by a series of buried flank faults that offset structural contours on the top of the Precambrian surface (Fig. 6). Hydrocarbon production localities (zip-a-tone patterns) also flank the platform. The axis of this large platform with its associated flank features trends about N 20 W. Immediately north of Hobbs, New Mexico the platform loses its identity as indicated by the structure contours, the lack of flank faults and the trend change of producing areas (Fig. 6).

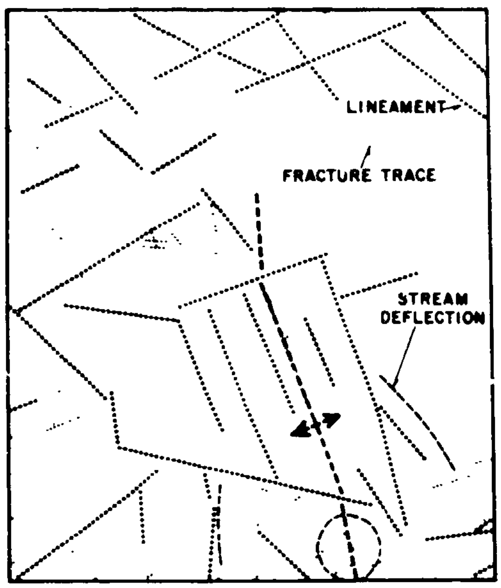

Fig. 7 - CENTRAL BASIN PLATFORM, WEST TEXAS ERTS DATA

Lineaments, fracture traces and geomorphic evidence mapped in the area on ERTS photos add a considerable amount of data in the area (Fig. 7). Combining the lineament-fracture data with the geomorphic evidence of stream deflections it is possible to infer an anticlinal axis inasmuch as the deflected stream evidence is suggestive of an anticlinal feature. The axis, however, cannot be inferred across the entire area because the lineament-fracture trace pattern changes to a northeast trend at the top of Figure 7.

Combining Figures 6 and 7 (Fig. 8) allows a direct comparison between the known data and the new data obtained from ERTS photos. In several localities the new lineaments nearly coincide with the known faults or with the flank producing areas. The inferred axis (Fig. 7) coincides with the crest of the platform as defined in Figure 6. Other more detailed comparisons can be made but an extremely interesting one is in the locality of Hobbs, New Mexico where the loss of platform identity and the change in production trend coincides well with the abrupt trend change in lineaments and fracture traces. More regional studies suggests that there may very well be a cause and effect relationship between the lineament trend change and the production trend change.

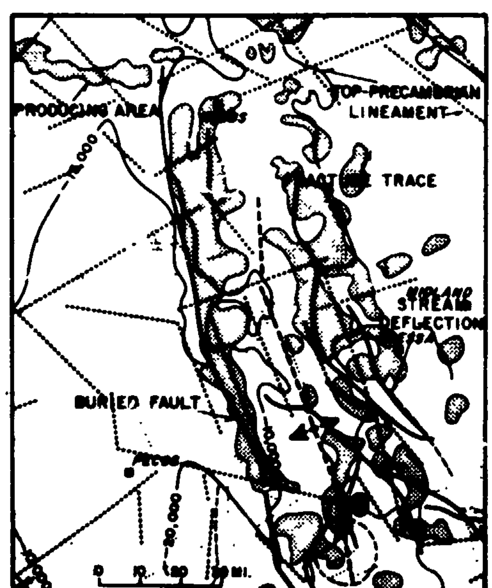

Fig. 8 - WEST TEXAS - COMBINED FEATURES.

CONCLUSIONS

The discernibility of geologic-geomorphic data on ERTS photos in west Texas that allow the surface reconnaissance mapping of a buried feature with a reasonable degree of accuracy indicates by itself the commercial value of ERTS imagery. The possibility of selecting prospective ore sites in relation to ERTS data as shown in the mining district of Arizona, New Mexico and Mexico adds to the commercial value of the imagery.

It can only be concluded from our results that ERTS-A imagery will be of tremendous value in commercial exploration programs. Regional studies of entire countries, over the worst possible terrain, will now be possible with the use of ERTS imagery. At the same time, the amount of data available should be sufficient to not only define regional basement features but also to localize more precise areas for further exploration.

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